



## **Direct and Residual Effect of Integrated Nitrogen Management on Physico-Chemical Properties of Soil**

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### **Authors' contributions**

This work was carried out in collaboration among all authors. Authors SRC, PVS, MML and VSR designed the study and wrote the protocol. Author DKDD performed the statistical analysis, wrote the first draft of the manuscript, managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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### **ABSTRACT**

**Aim:** To find out the direct and residual effect of integrated nitrogen management on physico-chemical properties of soil under rice – maize cropping system.

**Study Design:** The experiment was laid out in randomized block design during *kharif* season and in split plot design during *rabi* crop.

**Place and Duration of Study:** At Agricultural college farm, Bapatla during 2018-19 and 2019-20 in *Kharif* and *rabi* seasons.

**Methodology:** After the preliminary layout, paddy was sown in *kharif* and maize was sown in *rabi* season. Vermicompost and green leaf manure were applied two weeks before sowing of paddy. Treatments applied for paddy were considered as main plots and each one divided into two sub plots during *rabi*.

**Results:** Applications of different treatments did not show any significant difference in physico-chemical properties of soil (pH and EC) at all the growth stages of rice and maize during both the

years of study. Application of 75% RDN through green leaf manure + 25% RDN through inorganics (T<sub>5</sub>) to rice during *kharif* significantly improved organic carbon in both *kharif* and *rabi* seasons whereas different levels of fertilizers applied have not shown an significant influence on soil organic carbon content.

**Conclusion:** Application of inorganic fertilizers, organic manures and their combination didn't show marked difference on physico-chemical properties of soil like pH and EC. However substitution of 75% N through GLM in *kharif* season significantly improved OC content in soil during both *kharif* and *rabi* and organic carbon content was not influenced by the level of fertilizers from 50% RDF (S<sub>1</sub>) to 100% RDF (S<sub>2</sub>).

**Keywords:** Paddy; Maize; pH; electrical conductivity and organic carbon.

## 1. INTRODUCTION

In India rice-maize cropping system assumes prime importance under irrigated conditions. In Andhra Pradesh, rice is grown in an area of 2.16 million ha with annual production of 7.49 million tonnes and productivity of 3466 kg ha<sup>-1</sup> and maize is grown in an area of 0.23 million ha with annual production of 1.41 million tonnes and productivity of 6069 kg ha<sup>-1</sup> [1]. However, the cultivation of two cereal crops like rice and maize in quick succession on the same piece of land is not advisable with respect to soil health, resulting in decline in the yield of both crops.

This Rice-maize system is complicated because the component crops are grown in sharply contrasting physical, chemical and biological environments [2] where N losses are more pronounced. Here the role of soil organic matter becomes crucial, especially for maize as a supplier of secondary and micronutrients, and also as a natural "soil amendment" that creates a congenial soil physical environment for these crops. Organic matter becomes more important as most soils of South Asia currently have low organic matter contents. In this context, integrated nitrogen system, envisaging conjunctive use of inorganic and organic sources of nitrogen, could be considered for sustaining soil health and crop productivity [3-4].

Integrated nutrient management involving organic manures particularly vermicompost, green leaf manures and liquid formulations made using cow urine and cow dung viz., beejamrutham and jeevamrutham not only acts as a source of multiple nutrients and have ability to improve soil physical, chemical and biological properties and thus enhance crop productivity by means of maintaining soil health. In the light of above context, this experiment was planned to generate more information on contribution of integrated nitrogen management practices on soil properties under rice-maize cropping system.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

An experiment was conducted at Agricultural College Farm, Bapatla situated at 15° 54' N latitude and 80° 25' E longitude, at an altitude of 5.49 m above the mean sea level and is about 8 km away from the Bay of Bengal. The chemical analysis of soil showed that the soil is sandy clay loam in texture and low in available N (153.2 kg ha<sup>-1</sup>), medium in P (36.7 kg ha<sup>-1</sup>) and low in OC (0.44%) and K (341 kg ha<sup>-1</sup>) during 2017-18 respectively. The experiment was carried out in the same field during both the years. The experiment was laid out during *kharif* in a randomized block design with nine treatments viz., T<sub>1</sub>: Control, T<sub>2</sub>: 100% RDF through Inorganic fertilizers, T<sub>3</sub>: 100% Organic (Beejamrutham + Jeevamrutham), T<sub>4</sub>: 100% Organic (Beejamrutham and Jeevamrutham) + 25% RDN through inorganic fertilizers, T<sub>5</sub>: 75% RDN through Green leaf manure+ 25% RDN through inorganic fertilizers, T<sub>6</sub>: 75% RDN through vermicompost + 25% RDN through inorganic fertilizers, T<sub>7</sub>: 100% Organic (Beejamrutham and Jeevamrutham) + 50% RDN through inorganic fertilizers, T<sub>8</sub>: 50% RDN through Green leaf manure+ 50% RDN through inorganic fertilizers, T<sub>9</sub>: 50% RDN through vermicompost + 50% RDN through inorganic fertilizers and replicated thrice and in *rabi* each plot was divided into two subplots viz., 100% RDF and 50% RDF during both the years of study. Organic manures viz., Green leaf manure (*Glyricidia* sp.), vermicompost were applied as per the treatments fifteen days before sowing. The inorganic nitrogen (120 kg N ha<sup>-1</sup>) was applied through urea. Phosphorous (60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) and potassium (40 kg K<sub>2</sub>O ha<sup>-1</sup>) applied to all the plots except T<sub>3</sub> and T<sub>1</sub> considering their contents in the manures. Entire quantity of phosphorus and potassium and one third of the N were applied as basal at the time of sowing. Remaining inorganic N was applied in

two equal splits at active tillering stage and panicle initiation stages.

The *rabi* experiment was continued on the same site without disturbing the soil with maize as test crop to the study residual effect of different nitrogen sources applied to preceeding rice crop. During *rabi*, the treatments were consisted of two levels of fertilizers viz., S<sub>1</sub>- 50% RDF and S<sub>2</sub>- 100% RDF. Popular cultivars of rice and maize viz., BPT-5204 and Pioneer-3396 respectively, were chosen for the study.

## 2.2 Samples Collection and Analysis

In order to analyze the influence of soil properties on agronomic performance and to assess the impact of integrated nitrogen management on soil fertility, representative soil samples were taken from experimental plot and initial soil status was assessed. Soil samples were collected at different stages of rice and maize crops and analysed for pH, EC and OC content . Samples were taken from the cultivated soil layer (upper 15 cm), using a single auger. The samples were air-dried, crushed, and gravel and other particles of size more size than 2 mm were removed with a sieve. soil samples were drawn from individual plots from all the replications and analysed for pH, EC and organic carbon by following standard procedures [5-6].

## 2.3 Statistical Analysis

Statistical analysis of the experimental data was carried out as per the methods suggested by Gomez and Gomez [7] ANOVA was applied to analyse the data during both *kharif* and *rabi* seasons.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of INM on pH, EC And Organic Carbon Content of Soil under Rice

#### 3.1.1 Soil Reaction (pH)

The data pertaining to soil reaction presented in Table.1 revealed non significant difference between different nitrogen management practices at all the stages of rice crop and during both the years of study.

Close observation of data revealed decrease in the pH in all the treatments when compared to control (T<sub>1</sub>- 7.34, 7.2, 7.35 and 7.29, 7.26, 7.30

at knee high, tasseling and harvest stages respectively the years) during both the years of study. Reduction in pH with the application of organics when compared to control might be due to various organic acids (aminoacids, glycine and humic acid), acid forming compounds and CO<sub>2</sub> released from decomposition of organic manures [8]. The decomposition of organic manures plays an important role as H<sup>+</sup> pumping which also contributes to the soil pH decrement [9]. However, the non significant influence could be due to the production of organic acids by microbes and root exudates which act as weak acids and serve as excellent buffers. The production of organic acids during mineralization of organic materials by heterotrophs and nitrification by autotrophs would have caused this decrease in soil pH [10].

The results were in confirmity with the findings of Sarwar et al. [11] and Lalithkannan et al. [12]. Parvathi et al. [13] also reported non-significant results in soil pH by the use of organics.

#### 3.1.2 Electrical conductivity (EC)

The effect of different nitrogen management practices on changes in EC of soil was presented in Table.2 and indicated non-significant influence of treatments on electrical conductivity during two years of study. The treatments that received organics alone or in combination with inorganics decreased EC of soil compared to only inorganic treatment. Reduction of EC with combined application of organics and inorganics might be due to leaching of salts by the organic acids released by the organic sources [11] and [14]. The similar findings were reported by Sharma et al. [15].

The decomposition of organic materials released acids or acid forming compounds that reacted with the sparingly soluble salts already present in the soil and either converted them into soluble salts or at least increased their solubility [10]. Lower values of EC were recorded in control (T<sub>1</sub>) that received no fertilizers.

#### 3.1.3 Organic carbon

The results of the experiment pertaining to organic carbon (organic carbon) was presented in Table.3.

At all the three stages of crop, the significantly higher organic carbon was observed in treatment T<sub>5</sub> i.e., 75%N through green leaf

**Table 1. Effect of integrated use of inorganic fertilizers and organic manures on soil pH at different stages of rice**

Treatments	Kharif (2018)			Kharif (2019)		
	Tillering	Panicle Initiation	Harvest	Tillering	Panicle Initiation	Harvest
T <sub>1</sub>	7.34	7.32	7.35	7.29	7.26	7.30
T <sub>2</sub>	7.27	7.24	7.29	7.21	7.14	7.21
T <sub>3</sub>	7.32	7.31	7.33	7.28	7.26	7.29
T <sub>4</sub>	7.29	7.26	7.30	7.24	7.20	7.25
T <sub>5</sub>	7.14	7.11	7.18	7.11	7.06	7.11
T <sub>6</sub>	7.18	7.13	7.20	7.13	7.07	7.13
T <sub>7</sub>	7.28	7.25	7.29	7.23	7.18	7.23
T <sub>8</sub>	7.19	7.15	7.24	7.14	7.11	7.18
T <sub>9</sub>	7.22	7.19	7.25	7.19	7.15	7.21
SEm ±	0.34	0.31	0.29	0.32	0.29	0.33
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	8.07	7.38	7.02	7.77	7.10	7.85

**Table 2. Effect of integrated use of inorganic fertilizers and organic manures on EC (dSm<sup>-1</sup>) of soil at different stages of rice**

Treatments	Kharif (2018)			Kharif (2019)		
	Tillering	Panicle Initiation	Harvest	Tillering	Panicle Initiation	Harvest
T <sub>1</sub>	0.34	0.35	0.36	0.36	0.38	0.39
T <sub>2</sub>	0.46	0.51	0.53	0.54	0.55	0.56
T <sub>3</sub>	0.37	0.41	0.41	0.39	0.42	0.44
T <sub>4</sub>	0.43	0.50	0.50	0.51	0.52	0.53
T <sub>5</sub>	0.39	0.45	0.46	0.47	0.48	0.49
T <sub>6</sub>	0.41	0.44	0.46	0.46	0.47	0.48
T <sub>7</sub>	0.43	0.49	0.51	0.53	0.54	0.55
T <sub>8</sub>	0.42	0.47	0.48	0.49	0.50	0.51
T <sub>9</sub>	0.44	0.48	0.50	0.51	0.52	0.53
SEm ±	0.02	0.03	0.03	0.03	0.03	0.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	10.34	10.14	11.03	11.38	9.81	11.33

**Table 3. Effect of integrated use of inorganic fertilizers, organic manures on organic carbon (g kg<sup>-1</sup>) under rice at different stages**

Treatments	Kharif (2018)			Kharif (2019)		
	Tillering	Panicle Initiation	Harvest	Tillering	Panicle Initiation	Harvest
T <sub>1</sub>	4.30	4.20	4.10	4.20	4.10	4.00
T <sub>2</sub>	4.60	4.50	4.40	4.50	4.40	4.30
T <sub>3</sub>	4.50	4.40	4.30	4.30	4.20	4.10
T <sub>4</sub>	4.60	4.50	4.30	4.40	4.20	4.10
T <sub>5</sub>	5.80	5.60	5.40	6.40	6.10	5.80
T <sub>6</sub>	5.60	5.40	5.20	6.10	5.80	5.50
T <sub>7</sub>	4.60	4.50	4.40	4.40	4.30	4.20
T <sub>8</sub>	5.40	5.20	5.00	5.80	5.50	5.10
T <sub>9</sub>	5.20	5.10	4.90	5.60	5.30	5.00
SEm ±	0.18	0.19	0.19	0.18	0.19	0.17
CD (P=0.05)	0.55	0.57	0.56	0.55	0.57	0.51
CV (%)	6.40	6.81	6.95	6.24	6.80	6.33

manure + 25% RDN through inorganics (5.8, 5.6, 5.4 g kg<sup>-1</sup> and 6.4, 6.1, 5.8 g kg<sup>-1</sup>) and it was on a par with the treatments that received 75%N through vermicompost + 25% RDN through inorganics (T<sub>6</sub>- 5.6, 5.4, 5.2 and 6.1, 5.8, 5.5), 50% RDN through green leaf manure + 50% RDN through inorganics (T<sub>8</sub> – 5.4, 5.2, 5.0 g kg<sup>-1</sup> and 5.8, 5.5, 5.1 g kg<sup>-1</sup>) and 50% RDN through vermicompost + 50% RDN through inorganics (T<sub>9</sub>- 5.2, 5.1, 4.9 g kg<sup>-1</sup> and 5.6, 5.3, 5.0 g kg<sup>-1</sup>). The lowest organic carbon at all the three stages was recorded in absolute control treatment (T<sub>1</sub>- 4.3, 4.2, 4.1 g kg<sup>-1</sup> and 4.2, 4.1, 4.0 g kg<sup>-1</sup>) during 2018 and 2019 respectively.

The increase in soil organic carbon content in INM treatment might be attributed to higher contribution of biomass to the soil. The subsequent decomposition of these materials might have created environment conducive for formation of humic acid, stimulated the activity of soil microorganisms resulted in enhanced organic carbon content of the soil [16]. The increase in soil organic carbon content with organics had also been reported by Balvinderkumar et al. [17] Nandinidevi et al. [18].

The treatment that received only inorganics T<sub>2</sub> (4.6, 4.5, 4.4 and 4.5, 4.4, 4.3 g kg<sup>-1</sup>) recorded higher values of K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> carbon (organic carbon) when compared with the treatments that received 100% organics (Beejamrutham+ Jeevamrutham) i.e., T<sub>3</sub> (4.5, 4.4, 4.3 and 4.3, 4.2, 4.0 g kg<sup>-1</sup> soil) at active tillering, panicle initiation and harvest stages during both the years of study.

### 3.2 Residual Effect of Organics, Inorganics and their Combined Application on pH, EC and OC of Soil under Maize in Rice-Maize Cropping Sequence

#### 3.2.1 Soil reaction (pH)

Different nitrogen management practices applied in *kharif* showed non-significant residual effect on soil reaction (pH) at all the stages of maize crop and during both the years of study Tables 4 and 5.

However application of green leaf manure and vermicompost along with inorganics to rice crop resulted in more reduction in pH over control under maize when compared to all other treatments at all stages of maize. T<sub>1</sub> which received no fertilizers recorded more pH values when compared to all other treatments.

Irrespective of the treatments applied to preceding rice, the soil pH under succeeding maize decreased with increasing level of NPK from 50 to 100% during both the years of study but not at significant level. The results were in accordance with Mohan Rao et al. [4] Prasad et al. [19] also reported decrease in pH at harvest of maize crop due to continuous use of urea.

#### 3.2.2 Electrical conductivity (EC)

Different nitrogen management practices applied in *kharif* showed non-significant residual effect on soil EC at all the stages of maize crop and during both the years of study Tables 6 and 7.

Combined application of organics and inorganics reduced the EC of soil over complete inorganic treatment. whereas T<sub>1</sub> (control) and T<sub>3</sub> i.e sole organic treatment recorded lesser values of EC.

The application of 100% (beejamrutham+jeevamutham) in combination with inorganics recorded higher EC values when compared to green leaf manure and vermicompost. In rabi season, application of 100% RDF (S<sub>2</sub>) improved EC when compared to 50% RDF (S<sub>1</sub>) however the increase was insignificant. The interaction effect was also not significant.

#### 3.2.3 Organic carbon

The results of the experiment pertaining to organic carbon in *rabi* was presented in Tables 8 and 9. The data revealed significant residual effect of different treatments applied to rice on organic carbon content of soils under succeeding maize.

Irrespective of the levels of RDF applied to maize in *rabi*, application of green leaf manure and vermicompost to preceding rice have shown higher residual effect in terms of organic carbon in soil over all other treatments. Significantly higher organic carbon was recorded in treatment T<sub>5</sub> which received 75% RDN through green leaf manure + 25% RDN through inorganics (5.55, 5.35, 5.15 g kg<sup>-1</sup> in 2019 5.95, 5.65, 5.35 g kg<sup>-1</sup> in 2020) and it was on par with T<sub>6</sub> (75% N through vermicompost + 25% RDN through inorganics) (5.35, 5.15, 5.0 g kg<sup>-1</sup> in 2019 and 5.65, 5.35, 5.05 g kg<sup>-1</sup> in 2020) and followed by the treatment T<sub>8</sub> which received 50% RDN through inorganics + 50% RDN through green leaf manure (5.15, 4.95, 4.85 g kg<sup>-1</sup> in 2019 and 5.25, 5.10, 5.0 g kg<sup>-1</sup> in 2020). This might be due

**Table 4. Residual effect of INM practices in preceding rice and NPK levels on soil pH at different stages of maize (Rabi, 2019)**

	Knee High		Mean	Silking		Mean	Harvest		Mean
	S1	S2		S1	S2		S1	S2	
T1	7.34	7.33	7.34	7.33	7.32	7.33	7.36	7.34	7.35
T2	7.28	7.26	7.27	7.26	7.25	7.26	7.27	7.25	7.26
T3	7.32	7.30	7.31	7.32	7.31	7.32	7.33	7.31	7.32
T4	7.29	7.28	7.29	7.28	7.26	7.27	7.30	7.29	7.30
T5	7.19	7.17	7.18	7.19	7.15	7.17	7.21	7.20	7.21
T6	7.20	7.19	7.20	7.18	7.17	7.18	7.22	7.19	7.21
T7	7.27	7.27	7.27	7.26	7.24	7.25	7.29	7.26	7.28
T8	7.23	7.22	7.23	7.20	7.18	7.19	7.24	7.23	7.24
T9	7.24	7.23	7.24	7.22	7.20	7.21	7.26	7.23	7.25
Mean	7.26	7.25		7.25	7.23		7.28	7.26	
	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV (%)</b>
M	0.04	NS	7.4	0.04	NS	7.5	0.05	NS	7.5
S	0.11	NS	7.8	0.04	NS	7.8	0.06	NS	7.8
M X S	0.22	NS		0.07	NS		0.12	NS	
S X M	0.20	NS		0.08	NS		0.12	NS	

*M X S- For two sub plot means at the same level of main plot means  
S X M- For two main plot means at the same or different levels of sub plot means*



**Table 5. Residual effect of INM practices in preceding rice and NPK levels on soil pH at different stages of maize (Rabi, 2020)**

	Knee High		Mean	Silking		Mean	Harvest		Mean
	S1	S2		S1	S2		S1	S2	
T1	7.32	7.31	7.32	7.30	7.29	7.30	7.34	7.31	7.33
T2	7.25	7.24	7.25	7.23	7.21	7.22	7.25	7.24	7.25
T3	7.30	7.28	7.29	7.30	7.29	7.30	7.31	7.30	7.31
T4	7.27	7.24	7.26	7.25	7.23	7.24	7.28	7.25	7.27
T5	7.15	7.09	7.12	7.15	7.11	7.13	7.18	7.15	7.17
T6	7.18	7.14	7.16	7.16	7.12	7.14	7.21	7.17	7.19
T7	7.26	7.22	7.24	7.22	7.21	7.22	7.25	7.23	7.24
T8	7.19	7.15	7.17	7.15	7.15	7.15	7.21	7.19	7.20
T9	7.20	7.18	7.19	7.19	7.17	7.18	7.24	7.21	7.23
Mean	7.24	7.21		7.22	7.20		7.25	7.23	
	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV( %)</b>
M	0.04	NS	7.4	0.04	NS	7.7	0.04	NS	7.6
S	0.04	NS	7.6	0.04	NS	7.8	0.05	NS	7.7
M X S	0.08	NS		0.07	NS		0.10	NS	
S X M	0.05	NS		0.07	NS		0.09	NS	

**Table 6. Residual effect of INM practices in preceding rice and NPK levels on soil EC (dSm<sup>-1</sup>) at different stages of maize (*Rabi*, 2019)**

	Knee High		Mean	Silking		Mean	Harvest		Mean
	S1	S2		S1	S2		S1	S2	
T1	0.35	0.38	0.37	0.36	0.39	0.38	0.37	0.41	0.39
T2	0.49	0.51	0.50	0.50	0.54	0.52	0.53	0.56	0.55
T3	0.37	0.39	0.38	0.38	0.42	0.40	0.39	0.44	0.42
T4	0.46	0.48	0.47	0.48	0.50	0.49	0.49	0.52	0.51
T5	0.44	0.46	0.45	0.46	0.48	0.47	0.48	0.51	0.50
T6	0.43	0.44	0.44	0.44	0.46	0.45	0.46	0.48	0.47
T7	0.48	0.50	0.49	0.50	0.52	0.51	0.51	0.54	0.53
T8	0.46	0.47	0.47	0.48	0.49	0.49	0.50	0.52	0.51
T9	0.45	0.46	0.46	0.47	0.46	0.47	0.49	0.48	0.49
Mean	0.44	0.45		0.45	0.47		0.47	0.50	
	<b>SEm<sub>±</sub></b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm<sub>±</sub></b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm<sub>±</sub></b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>
M	0.03	NS	6.7	0.04	NS	6.9	0.02	NS	6.9
S	0.02	NS	6.5	0.03	NS	6.8	0.02	NS	6.8
M X S	0.04	NS		0.06	NS		0.05	NS	
S X M	0.04	NS		0.06	NS		0.05	NS	

Table 7. Residual effect of INM practices in preceding rice and NPK levels on soil EC (dSm<sup>-1</sup>) at different stages of maize (*Rabi*, 2020)

	Knee High		Mean	Silking		Mean	Harvest		Mean
	S1	S2		S1	S2		S1	S2	
T1	0.39	0.41	0.40	0.40	0.42	0.41	0.41	0.43	0.42
T2	0.51	0.54	0.53	0.54	0.58	0.56	0.56	0.61	0.59
T3	0.39	0.41	0.40	0.41	0.43	0.42	0.43	0.45	0.44
T4	0.47	0.49	0.48	0.49	0.51	0.50	0.51	0.53	0.52
T5	0.46	0.48	0.47	0.49	0.51	0.50	0.52	0.54	0.53
T6	0.45	0.47	0.46	0.47	0.49	0.48	0.49	0.51	0.50
T7	0.49	0.51	0.50	0.51	0.53	0.52	0.53	0.55	0.54
T8	0.47	0.51	0.49	0.50	0.54	0.52	0.53	0.57	0.55
T9	0.47	0.49	0.48	0.49	0.51	0.50	0.51	0.53	0.52
Mean	0.46	0.48		0.48	0.50		0.50	0.52	
	SEm <sub>±</sub>	CD (p=0.05)	CV(%)	SEm <sub>±</sub>	CD (p=0.05)	CV(%)	SEm <sub>±</sub>	CD (p=0.05)	CV( %)
M	0.04	NS	6.9	0.02	NS	6.9	0.02	NS	6.7
S	0.03	NS	6.7	0.01	NS	6.7	0.03	NS	6.7
M X S	0.06	NS		0.03	NS		0.05	NS	
S X M	0.06	NS		0.03	NS		0.05	NS	

**Table 8. Residual effect of INM practices in preceding rice and NPK levels on organic carbon (g kg<sup>-1</sup>) in soil at different stages of maize (*Rabi*, 2019)**

	Knee High		Mean	Silking		Mean	Harvest		Mean
	S1	S2		S1	S2		S1	S2	
T1	4.20	4.30	4.25	4.10	4.20	4.15	4.00	4.10	4.05
T2	4.50	4.60	4.55	4.40	4.50	4.45	4.30	4.40	4.35
T3	4.40	4.50	4.45	4.30	4.40	4.35	4.20	4.30	4.25
T4	4.40	4.50	4.45	4.30	4.40	4.35	4.20	4.30	4.25
T5	<b>5.50</b>	<b>5.60</b>	<b>5.55</b>	<b>5.30</b>	<b>5.40</b>	<b>5.35</b>	<b>5.10</b>	<b>5.20</b>	<b>5.15</b>
T6	<b>5.30</b>	<b>5.40</b>	<b>5.35</b>	<b>5.10</b>	<b>5.20</b>	<b>5.15</b>	<b>4.90</b>	<b>5.10</b>	<b>5.00</b>
T7	4.50	4.60	4.55	4.40	4.50	4.45	4.30	4.40	4.35
T8	5.10	5.20	5.15	4.90	5.00	4.95	4.80	4.90	4.85
T9	5.00	5.10	5.05	4.80	4.90	4.85	4.70	4.80	4.75
Mean	4.77	4.87		4.62	4.72		4.50	4.61	
	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm±</b>	<b>CD (p=0.05)</b>	<b>CV( %)</b>
M	0.127	0.38	6.46	0.121	0.36	6.4	0.108	0.33	6.0
S	0.056	NS	6.09	0.061	NS	6.8	0.055	NS	6.2
M X S	0.175	NS		0.177	NS		0.159	NS	
S X M	0.169	NS		0.183	NS		0.164	NS	

**Table 9. Residual effect of INM practices in preceding rice and NPK levels on organic carbon (g kg<sup>-1</sup>) in soil at different stages of maize (*Rabi*, 2020)**

	Knee High		Mean	Silking		Mean	Harvest		Mean
	S1	S2		S1	S2		S1	S2	
T1	4.10	4.20	4.15	4.00	4.10	4.05	4.00	4.00	4.00
T2	4.40	4.50	4.45	4.30	4.40	4.35	4.20	4.30	4.25
T3	4.20	4.30	4.25	4.10	4.20	4.15	4.00	4.10	4.05
T4	4.20	4.30	4.25	4.10	4.20	4.15	4.10	4.10	4.10
T5	5.90	6.00	5.95	5.60	5.70	5.65	5.30	5.40	5.35
T6	5.60	5.70	5.65	5.30	5.40	5.35	5.00	5.10	5.05
T7	4.30	4.40	4.35	4.20	4.30	4.25	4.10	4.20	4.15
T8	5.20	5.30	5.25	5.00	5.20	5.10	4.90	5.10	5.00
T9	5.10	5.20	5.15	4.90	5.10	5.00	4.80	5.00	4.90
Mean	4.78	4.88		4.61	4.73		4.49	4.59	
	<b>SEm<sub>±</sub></b>	<b>CD (p=0.05)</b>	<b>CV (%)</b>	<b>SEm<sub>±</sub></b>	<b>CD (p=0.05)</b>	<b>CV(%)</b>	<b>SEm<sub>±</sub></b>	<b>CD (p=0.05)</b>	<b>CV (%)</b>
M	0.120	0.36	6.1	0.115	0.34	6.0	0.128	0.38	6.9
S	0.056	NS	6.0	0.055	NS	6.1	0.045	NS	6.0
M X S	0.168	NS		0.164	NS		0.160	NS	
S X M	0.167	NS		0.165	NS		0.136	NS	

to the direct incorporation of organic matter, better root growth and more plant residues addition [20] Singh et al. [21] and Kumar and Singh [22] also reported buildup of organic carbon in the soil with combined application of organics and inorganics to preceding crop.

The lowest organic carbon was recorded in treatment T<sub>1</sub> i.e., control (4.25, 4.15, 4.05 and 4.15, 4.05, 4.00 g kg<sup>-1</sup> soil) at all the stages of maize and during both the years. Application of inorganic fertilizers (T<sub>2</sub>-4.55, 4.45, 4.35 g kg<sup>-1</sup> in 2019 and 4.45, 4.35, 4.25 g kg<sup>-1</sup> in 2019) improved the organic carbon content in soil when compared to treatments which received 100% organic (beejamrutham+jeevamrutham) alone (T<sub>3</sub>-4.45, 4.35, 4.25g kg<sup>-1</sup> in 2019 and 4.25, 4.15, 4.05 g kg<sup>-1</sup> in 2019).

The sub plot treatments i.e., 100% RDF and 50% RDF have not shown any significant effect on K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> carbon content in soil. However increase in fertilizer level from 50 % (S<sub>1</sub>) to 100% RDF (S<sub>2</sub>-4.87, 4.72, 4.61 g kg<sup>-1</sup> and 4.88, 4.73, 4.59 g kg<sup>-1</sup>) increased the K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> carbon in soil during 2019 and 2020. The increase in organic carbon content in soil with application of higher doses of N, P, K had also been reported by Banwasi and Bajpai [23] Sujatha et al. [24] Vandana et al. [25].

The interaction between nitrogen management treatments and levels of RDF was found non significant. But highest OC was observed in T<sub>5</sub>S<sub>2</sub> (75% RDN through Green leaf manure + 25% RDN through inorganics in *kharif* and 100 % RDF in *Rabi*) while the lowest OC was recorded in T<sub>1</sub>S<sub>1</sub> (Control in *kharif* and 50% RDF in *rabi*).

1. Different nitrogen management treatments did not show any significant direct or residual effect on soil physico-chemical properties (pH and EC) at all the growth stages of rice and maize during both the years of study. Similar results were quoted by Mohan rao et al. [4] Sankaramoorthy et al.,[14]. However application of 75% RDN through green leaf manure + 25% RDN through inorganics (T<sub>5</sub>) to rice significantly improved the soil organic carbon content in *kharif* when compared to all other treatments. In *rabi*, treatment T<sub>5</sub> S<sub>2</sub> which received 75% RDN through green leaf manure + 25% RDN through inorganics in *kharif* season and 100% RDF in *rabi* recorded significantly highest OC content in soil. Singh et al. [26] and Kumar and Singh [27] also reported buildup of organic carbon in the soil with combined application of organics and inorganics to preceding crop.

2. Decomposition of organic matter release organic acids into the soil which reduces the pH of the soil [8] and the acids released also have solublizing effect on salts in the soil [10] thus reducing the EC of soil. The increased root biomass and root exudates with the combined application of organic manures fertilizers might have resulted in higher carbon content in soil. The persistant material in organic manures viz., cellulose, requires more time for its decomposition, hence, highest organic carbon content was observed in the treatment where 75% N was substituted through organic manure during both *kharif* and *rabi* Patel et al.

#### 4. CONCLUSIONS

- Application of inorganic fertilizers, organic manures and their combination didn't show marked difference on physico-chemical properties of soil like pH and EC. Among the treatments application of 75% RDN through green leaf manure + 25% RDN through inorganics recorded significant direct and residual effect on organic carbon content in soil i.e., T<sub>5</sub> resulted in higher values of organic carbon during both *kharif* and *rabi*. In *rabi*, the organic carbon content was not influenced by the level of fertilizers i.e., 50% RDF (S<sub>1</sub>) and 100% RDF (S<sub>2</sub>). Future research may be carried out to consider the potential effect of imposed treatments on N, P, K fractions in soil and also to test the treatments in other important cropping systems viz., rice-millet, cereal-pulse etc.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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